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OBSERVATIONS ON THE SPIDER FAUNA OF GEOGRAPHICALLY ISOLATED WETLANDS IN SOUTHWESTERN GEORGIA

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ABSTRACT

A study of the spiders occurring in three types of isolated wetlands (marshes, savannas, and swamps) in southwestern Georgia was conducted in the fall of 2005 and the spring of 2006 using 30 one meter long sweep net passes per wetland. Twenty-seven taxa from nine families of spiders were observed. Tetragnathidae and Pisauridae were the most common spider types with marsh wetlands having the greatest richness and abundance. Species found were mostly those associated with aquatic habitats; *Dolomedes triton* being the most abundant with an overall mean density of 1.29/m^2. Patterns of spider richness and abundance were similar to patterns observed for other wetland invertebrates, i.e., greatest in marshes. Life history requirements for spiders occupying isolated wetlands in the longleaf pine landscape appear to be excellent dispersal ability for recolonizing following frequent and heterogeneous fires, and flexibility in habitat preference enabling persistence during frequent cycles of wetting and drying.

Keywords: isolated wetlands, marshes, savannas, swamps, spiders, Pisauridae, Tetragnathidae, *Dolomedes*, *Tetragnatha*

INTRODUCTION

Geographically isolated wetlands are an important habitat type found in the southeastern United States, providing important ecosystem services including habitat for unique plants and animals, filtration of water, floodwater storage, and facilitation of ground water exchange (NRCS 2007; Smith and Golladay 2011; Kirkman et al. 2012). Kirkman et al. (2000) noted that isolated wetlands are at risk of degradation due to their small size and lack of legal protection. In recognition of their significant ecosystem services, Semlitsch and Bodie (1998) suggested that the relative contribution of these wetlands to regional diversity is disproportionate to their total area. Kirkman et al. (2012) also note the importance and complex ecology of southeastern isolated wetlands embedded within a matrix of human dominated and natural uplands.

Many geographically isolated wetlands are found on the Coastal Plain physiographic province (Kirkman et al. 2012). Their distribution corresponds with the historical distribution of the longleaf pine forest, a landscape also noted for floral and faunal diversity. With the loss of longleaf pine uplands and conversion to a variety of human land uses, isolated wetlands are subject to alteration and degradation. Few

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examples of undisturbed longleaf forest and associated wetlands remain (Kirkman et al. 2012).

Significant progress has been made in documenting the flora and fauna of the remaining longleaf pine landscape and associated wetlands (Kirkman et al. 1999; Liner et al. 2008; Battle and Golladay 2001; Smith and Golladay 2011). However, little is known about the spider fauna of these wetlands. Spiders are important predators and are thus important intermediaries in food webs and are encountered frequently in these isolated wetlands.

This preliminary study was conducted to gain a better knowledge of the spider species found on the water surface and emergent vegetation of three wetland types.

METHODS

Field Sites

Our research was conducted near Newton, Georgia, at the J. W. Jones Ecological Research Center at Ichauway (headquarters at latitude 31.2106 north, longitude 84.4739 west), a 12,000 ha reserve that has been managed for several decades with prescribed fire to maintain and restore the longleaf pine (*Pinus palustris* Miller) forest and wiregrass (*Aristida stricta* Michx.) dominated groundcover. The reserve contains more than 30 geographically isolated wetlands and several ephemeral depressions (Smith et al. 2006), which are minimally influenced by human activity. The seasonal and interannual variability of hydrology and diverse vegetation represent excellent reference conditions (Kirkman et al. 2012). Fire return intervals in the uplands are generally 2 years. Fire is allowed to move freely into wetlands, being limited only by availability of flammable fuels and degree of inundation.

Wetlands in this study were previously classified into one of three types: marshes, savannas, or swamps (Kirkman et al. 2000). Marshes have sandy bottom soil with vegetation consisting of panic grass (*Panicum* spp.) and cut grass (*Leersia hexandra* Sw.). Savannas have clayey soils with a sparse distribution of pond cypress (*Taxodium ascendens* Brong.) and ground-flora consisting of panic grasses and broomsedge (*Andropogon virginicus* L.). Swamps have organic soils with pond cypress and swamp tupelo (*Nassa biflora* Walt.) overstory and sparse midstory and ground flora of various species. Three of each wetland type were selected for sampling, and were among a larger set of wetlands that are a part of long-term hydrologic, water quality, and ecological monitoring program.

Sampling

Survey sampling was done during periods of wetland inundation and water depths at sampling sites ranged from a few centimeters to a meter or so in the wetlands (September 30 through October 21, 2005, and March 1 through 9, 2006). Since spider sampling occurred during inundation usual sampling techniques such as typical pit fall traps could not be used. Thirty 1 m^2 surface samples were taken in each wetland on each sampling date. Each sample was taken by making three sweeps in a meter long *Z* fashion with a 1 mm^2 mesh D frame sweep net across the water surface and emergent vegetation. If there was dense vegetation (i.e., emergent grasses) more sweeps through the same area

of grasses were necessary to dislodge spiders. For swamps and savannas a variety of habitats including vines alongside logs, detritus, as well as grasses were sampled along the water surface. Spiders were removed from the sweep net following each series of sweeps. During fall sampling, after familiarity with identity was developed (with voucher specimens preserved in alcohol), recognized species were released and only new or unfamiliar species were preserved. This was done with the intent of conserving spiders. However, during the spring sampling, all spiders collected were placed in a vial of alcohol along with collecting information. Because of this sampling procedure only those specimens preserved in the fall were available for further analysis, while all specimens collected in the spring were available for further study. Voucher spiders from the study are archived at the Georgia Museum of Natural History in Athens, Georgia.

Fall specimens were identified to species where possible by one of the authors (SB) either in the field or in the lab. Identification was based on Kaston (1978) or Ubick et al. (2005). Spring specimens were all identified in the lab by another author (WT), who also reviewed the identity of the preserved fall specimens. Since there were few unusual spiders present, identification to genus was possible for most specimens, and a clear indication of species was often possible. Kaston (1948) was used to confirm *Dolomedes* and *Tetragnatha* identifications. Gaddy (2009) and Bradley (2013) were also used as references to confirm or provide better understanding in cases of identification problems. World Spider Catalogue Version 15.0, July 2014, was used to confirm the taxa used.

Statistical Analysis

Nonmetric multidimensional scaling (NMS, McCune and Grace 2002) was used for exploratory data analysis of density (number per square meter) of major spider groups, taxa richness, and total spider abundance by wetland and sample date. A preliminary six dimensional solution was performed comparing stress versus iteration for randomized and real data. Based on the results of a randomization test, a two dimensional solution was selected for the final ordination using the best fit configuration from the preliminary ordination as a starting point for analysis (e.g., McCune and Grace 2002, PCord V6, MjM Software Design, Gleneden Beach, Oregon).

Indicator species analysis (Dufrene and Legendre 1997) was used to examine the affinity of particular spider groups for wetland types. The analysis uses a combination of abundance, presence, and fidelity with a collection site, i.e., wetland type, to calculate a single value ranging from zero (no indicator) to 100 (perfect indicator) for each taxonomic group (Dufrene and Legendre 1997, PCord V6, MjM Software Design, Gleneden Beach, Oregon).

RESULTS

Twenty-six taxa of spiders from nine families were observed in the three wetland types during the study (Table I). Marshes generally had the greatest abundance of spiders with two families, Tetragnathidae and Pisauridae, being the most abundant faunal groups (Table I). The most abundant species was *Dolomedes triton* (Walckenaer) at all wetland types in both fall and spring. *Tetragnatha laboriosa* Hentz was second in abundance, being very common in fall marsh samples. Other spider taxa were considerably less common than *D. triton* and *T. laboriosa*.

Table I. Spider taxa and abundance in three types of geographically isolated wetlands in southwestern Georgia. Mean abundance represents the total of 30 1-m² collections in three wetlands of each type listed on two dates.

	Fall 2004 (# wetland⁻¹)						**Spring 2005** (# wetland⁻¹)					
	Marsh		Swamp		Savanna		Marsh		Swamp		Savanna	
	mean	Std	mean	Std	mean	Std	mean	Std	mean	Std	mean	Std
Small Linoyphiid Like	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.2	2.0	2.0	1.0	1.7
Tetragnathidae												
Pachygnatha sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6
Tetragnatha laboriosa Hentz	17.7	17.6	5.3	3.2	6.3	5.1	4.0	3.5	1.0	1.7	0.0	0.0
Tetragnatha versicolor Walck.	0.0	0.0	0.0	0.0	0.3	0.6	5.0	3.5	4.0	2.6	0.3	0.6
Tetragnatha elongata Walck.	9.7	2.5	2.3	2.3	3.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0
Total Tetragnathidae	27.3	19.7	7.7	5.5	10.3	2.5	9.0	6.9	5.0	1.0	0.7	0.6
Agelenidae												
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0
Pisauridae												
Dolomedes scriptus Hentz	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Dolomedes tenebrosus Hentz	0.3	0.6	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Dolomedes triton Walck.	24.3	17.2	23.0	13.0	30.7	6.0	67.7	38.4	34.0	5.2	53.3	12.5
Pisaurina undulata Keyserling	1.7	1.2	1.7	2.9	0.3	0.6	5.7	6.7	3.0	4.4	7.7	2.5
Total Pisauridae	26.3	16.3	24.7	15.9	31.7	5.0	73.3	36.1	37.0	5.3	61.0	10.0
Lycosidae												
Pardosa sp.	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.7	0.3	0.6	0.0	0.0
Pirata sp. a	0.7	1.2	0.0	0.0	0.0	0.0	6.0	2.6	4.0	3.0	7.0	5.3
Pirata sp. b	0.3	0.6	0.3	0.6	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Sosippus sp.	0.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table I (continued)

	Fall 2004 (# wetland^{-1})						**Spring 2005** (# wetland^{-1})					
	Marsh		Swamp		Savanna		Marsh		Swamp		Savanna	
	mean	Std	mean	Std	mean	Std	mean	Std	mean	Std	mean	Std
Trabeops aurantiacus (Emert.)	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trochosa sp.	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lycosidae	3.3	3.1	0.3	0.6	1.0	1.0	7.0	2.6	4.3	3.5	7.0	5.3
Clubionidae												
Clubiona sp.	1.7	2.9	0.3	0.6	0.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Salticidae												
Plexippus paykulli (Audouin)	1.3	1.5	0.0	0.0	0.0	0.0	6.0	7.8	0.7	0.6	3.3	3.1
Maevia sp	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Marpissa sp.	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Menemerus sp	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metacyrba sp.	2.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salticus sp	0.0	0.0	0.7	1.2	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Lyssomanes viridis (Walck.)	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Salticidae	4.3	1.5	1.0	1.0	0.3	0.6	6.0	7.8	0.7	0.6	3.3	3.1
Philodromidae												
Philodromus sp.	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.3	0.6
Araneidae												
Larinia sp.	0.7	0.6	0.0	0.0	2.7	3.8	0.0	0.0	0.0	0.0	0.0	0.0
Total Spiders	62.0	15.1	33.7	21.9	46.3	4.9	97.0	51.0	49.0	10.8	73.3	18.4

The two dimensional solution selected for NMS explained 98% of the variation in the spider data (axis 1: 81%, axis 2: 17%) (Figure 1). Species richness, Tetragnathidae abundance, and Clubionidae abundance were positively correlated with axis 1 (r = 0.94, 0.58, and 0.45, respectively). Generally marshes had the greatest taxa richness and abundance of Tetragnathidae and Clubionidae, particularly in the fall samples. Swamps generally had the lowest richness and abundance of tetragnathids and clubionids. Total spider abundance, Pisauridae, and Lycosidae abundance were positively correlated with axis 2 (r = 0.63, 0.83, and 0.58, respectively). Spring samples from marshes and savannas generally had the greatest spider abundance and abundance of pisaurids and lycosids (Figure 1). Indicator species analysis showed strong fidelity between Tetragnathidae and Salticidae and marshes (IV 60.6, p = 0.03; IV 66.5, p = 0.03, respectively). No other taxa groups showed strong associations with particular wetland types.

DISCUSSION

General Patterns

This appears to be the first general population study of the spiders in isolated wetlands in the southeastern United States. Studies have examined other aquatic habitats and looked at particular types of spiders, but not on a general population level. It is also unique in that spiders were sampled during wetland inundation, i.e., collections were made on emergent vegetation completely surrounded by water of various depths.

The majority of the spiders found in these wetlands are known to be associated with the aquatic habitat. *D. triton*, the most abundant species, is associated with wetlands, as are other *Dolomedes* species, but *D. scriptus* Hentz is more associated with faster running water and *D. tenebrosus* Hentz is generally observed away from water, often on trees (Gaddy 2009). Tetragnathidae are also associated with aquatic habitats. Other spiders identified in this study associated with aquatic habitats include *Pardosa milvina* Hentz, *Trabeops aurantiacus* (Emerton), and *Pirata minutus* Emerton (Bradley 2013; Kaston 1978; Gaddy 2009). The remaining spiders observed might reflect chance occurrences or marginal associations.

Several small linyphiid like spiders were found in marshes, swamps, and savannas (one) in the spring but were absent in the fall. Ubick et al. (2005) noted that the linyphiids occupy almost all habitats including wetlands. These are noted for their dispersal by 'ballooning', which contributes to their widespread distribution (Ubick et al. 2005).

Bradley (2013) notes that ballooning accounts for the rapid recolonization of spiders in areas following disturbances such as flooding and fire. Given that the wetlands we studied represent isolated aquatic habitats in a fire-maintained landscape, subject to biennial prescribed fire (Kirkman et al. 2012), ballooning may provide means for dispersal particularly into the more fire-prone marshes and savannas. Buchholz and Schroder (2013) observed that several of the families or even genera found in this study demonstrated ballooning traits including Araneidae, several Lycosidae (*Pardosa* and *Pirata*), *Philodromus,* and *Pisaurina*.

Suter (2013) reviewed and discussed locomotion on water surface by various spider types, noting that successful movement must be paramount to successful utilization of aquatic habitats. Clearly, spiders occupying water-filled wetlands must have

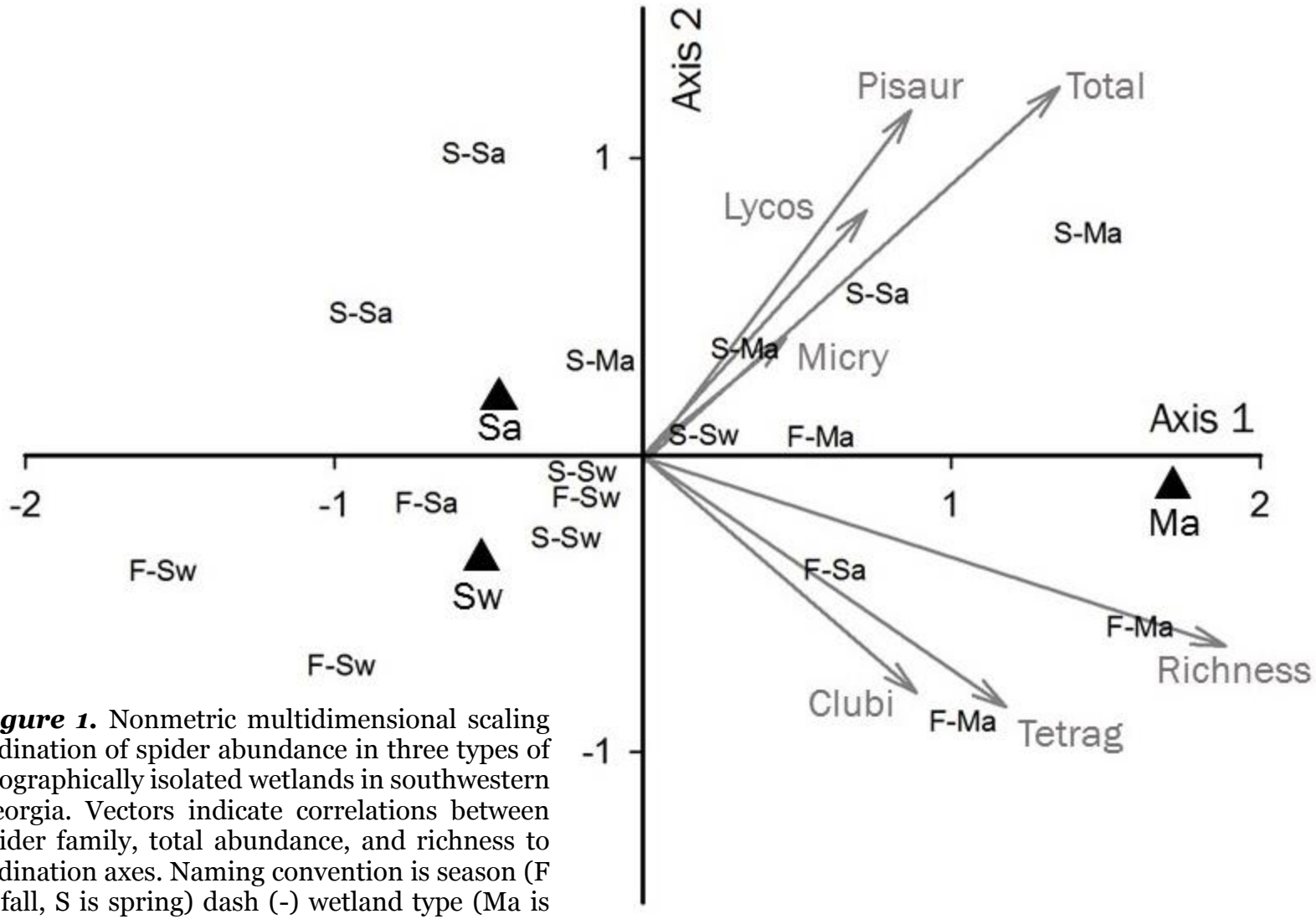

Figure 1. Nonmetric multidimensional scaling ordination of spider abundance in three types of geographically isolated wetlands in southwestern Georgia. Vectors indicate correlations between spider family, total abundance, and richness to ordination axes. Naming convention is season (F is fall, S is spring) dash (-) wetland type (Ma is marsh, Sw is swamp, and Sa is savanna). Filled triangles represent centroids for wetland type.

behaviors and anatomical features allowing successful movement on water surface. Locomotor adaptations of *Dolomedes*, tetragnathids, and lycosids are included in Suter's review (Suter 2013).

The wandering hunting habits of lycosids are likely important for their successful utilization of wetlands. Wetland habitats are interspersed within various terrestrial microhabitats which are likely preferred by a variety of lycosids, clubionids, and salticids. Based on their comparative study of adjacent pine forest and bogs in Lithuania, Relys and Dapkus (2000) noted that dispersal from dry pine forest had little influence on adjacent peatbog spider assemblages. In contrast, Draney (1997) concluded that spillover between habitats occurs in Georgia floodplains and is likely important in maintenance of biodiversity. Draney (1997) also noted that certain spider species that were abundant in some habitats were absent in differing adjacent habitats. Given the frequency and heterogeneity of fire in the longleaf pine landscape, spiders found in isolated wetlands would need excellent dispersal capability and some tolerance for habitat variability.

Spiders that live in orb webs such as the araneids and tetragnathids need structure to attach webs. Each of the three wetland types provides such structure but emergent vegetation was much less common in swamps compared to marshes and savannas (Battle and Golladay 2001). Araneid abundance was low but they were found only in marshes and savannas. Tetragnathids also need structure to attach webs. Others such as *Dolomedes* need both structure such as emergent grasses in which to hide and open water surface for hunting. In a study of vertical structural complexity of macrophyte stands in a Brazilian river, Cunha et al. (2012) concluded that vertical structural complexity was the most important driver of spider abundance and diversity in macrophyte stands of a Brazilian river. Our observations on spider assemblages in marshes and savannas are consistent with those results.

Comparisons with Studies of Specific Taxonomic Groups

Pirata occurs in low abundance in each wetland type in our study. Relys and Dapkus (2000) reported that *Pirata uliginosus* Thorell was an abundant species in a pine bog they studied in Lithuania. In a study of a Mississippi salt marsh, LaSalle and De La Cruz (1985) reported densities of 17.8 *Pirata*/m^2. The greatest density of *Pirata* found in our wetlands was 0.37/m^2 in one of the savannas in the spring collection. Relys and Dapkus (2000) also reported that *Pardosa sphagnicloa* Dahl was an important species in their open bog and their pine bog in contrast to the small numbers of *Pardosa* in our wetlands. They also report finding only a single *Dolomedes*, *D. fimbriatus* Clerck, (in an open bog) out of a total of 2,577 specimens collected in their study.

In a study of a small Canadian pond using pitfall trapping, Graham et al. (2003) found that *D. triton* comprised less than thirty percent of pond surface and near-shore spiders with *Pirata* constituting the major group. In a Michigan *Typha* retention pond, Cummins (2007) found that the most common spiders were lycosids, followed by clubionids, and least abundant being tetragnathids, with no report of *Dolomedes*. Jordan et al. (1994) found that overall *D. triton* density was 0.1 spiders/m^2 in an Everglades sawgrass community, ranging from a peak of 0.3/m^2 in May to no spiders in the earlier spring. Beckmann and Rovner (1984) found an average of 0.3 *Dolomedes* per meter of

shoreline of an Ohio lake. Zimmerman and Spence (1992) give approximate densities of 0.1–0.3 spiders/m^2 with peak densities of 1.1/m^2 for a small Canadian lake.

The differences between the reported numbers in the studies cited above may be the results of the differences between sampling methods. Sweep net sampling may be less effective, thus results in smaller numbers. However, if that is the case, then it is interesting that the densities of *D. triton* we found appear to be greater than those reported elsewhere. In our study *D. triton* averaged 0.87/m^2 in the fall and 1.72/m^2 in the spring with an overall mean of 1.29/m^2. The least density observed was 0.4/m^2 in one of the marshes in the fall and the largest was 3.7/m^2 in one of the marshes in the spring. One fall sample in a savanna had six *D. triton* and in the spring one swamp had 11, one savanna had 12 and one marsh had 13/m^2.

In an intensive study of *Tetragnatha* spiders in the Great Smoky Mountains, Aiken and Coyle (2000) reported habitat preferences for several species also found in the southwestern Georgia wetlands. They found that *T. versicolor* Walckenaer is common in a wide variety of habitats including wetlands. We found this spider in all wetlands except two of the savannas in the spring collection. Aiken and Coyle (2000) suggested that *T. laboriosa* is virtually restricted to nonwetland grassy habitats whereas it was common to abundant in all of our wetlands in the fall and three in the spring. They also found that *T. elongata* Walckenaer was strictly riparian, nearly always building its webs over open water, reporting that it was only collected over the small streams. However we found *T. elongata* in all of the fall wetland collections, being second in abundance in the marshes. However, it was not found in any of our spring collections.

Conclusions

The greater abundance and diversity of spiders observed in savannas and marshes in this study is consistent with previous studies of aquatic macroinvertebrates. Battle and Golladay (2001) also noted greater abundance of aquatic invertebrates in marshes and savannas, which they attributed to greater habitat complexity of emergent vegetation providing diverse microhabitats for immature aquatic insects. Given that a majority of aquatic insects found in our study sites have terrestrial dispersal stages (Battle and Golladay 2001), greater abundance of spiders in marshes and savannas may reflect an abundance of potential prey. In addition to prey abundance, hydrologic isolation and periodic drying excludes fish, a potential predator. While the taxonomic richness of spiders may not be comparable to other groups of invertebrates, their abundance may make them important intermediaries in wetland foodwebs by linking terrestrial and aquatic components. The differences in diversity and abundance we observed appear to reflect the structural complexity of wetland habitats, consistent with previous studies of wetland invertebrates (e.g., Battle and Golladay 2001) and consistent with studies of spiders in other aquatic habitats (Cunha et al. 2012). Life history characteristics of spiders occupying isolated wetlands in the longleaf pine landscape would appear to be an excellent ability to recolonize following frequent and heterogeneous fires and some degree of flexibility in preference of habitat, enabling persistence during cycles of wetting and drying.

It is important to recognize that since these were pond-like wetlands at sampling times, only sweep net collection was used in this study, as in contrast to the methods used in some of the other studies cited. It must be recognized that because of method limitations this in no way constitutes an exhaustive species list of these isolated wetlands, but rather a study of the species present during wetland inundation.

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